Downhole logging (Cross well Seismic) Applications from the Oil field to Mining

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* Mark of Schlumberger
Agenda

• Introduction

• Acquisition

• Case Studies
Crosswell measurements target the reservoir
Resolution scales in reservoir interpretation

Increasing vertical resolution

Surface  Crosswell EM  Crosswell Seismic  Logs  Core

After Harris et al. (1995)
Imaging seismic between wells

**Surface Seismic**

**Crosswell Seismic**

Typical Source Frequency Ranges

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Frequency Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Seismic</td>
<td>5-120Hz</td>
</tr>
<tr>
<td>VSP</td>
<td>5-200Hz</td>
</tr>
<tr>
<td>Crosswell Seismic</td>
<td>30-800Hz (clamped)</td>
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<tr>
<td></td>
<td>100-2000Hz (piezoelectric)</td>
</tr>
</tbody>
</table>
Crosswell seismic solutions

- High-resolution reservoir characterization
- Development planning
- 4D monitoring - IOR/EOR
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Crosswell seismic acquisition

- Wireline deployed fluid-coupled or magnetically clamped seismic source
- Level Spacing 2.5, 5 or 10 ft

Wireline deployed single-component or 3C Multi-Level Receiver Array
- Receiver Array Moved 50 or 100 ft
- Receiver Array Stationed at Position of Deepest Zone

One profile for per source position (profile)

Resolution is dependent on:
- Frequency
- Formation attenuation
- Interwell distance
## Acquisition considerations

<table>
<thead>
<tr>
<th>Transmitter Well</th>
<th>Receiver Well</th>
<th>Max Spacing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piezo Source</td>
<td>Hydrophones/3C</td>
<td>1000m</td>
</tr>
<tr>
<td>Any casing</td>
<td>Any casing</td>
<td></td>
</tr>
<tr>
<td>Clamped Source</td>
<td>Hydrophones/3C</td>
<td>2500m</td>
</tr>
<tr>
<td>Steel or Magnetic Cr</td>
<td>Any</td>
<td></td>
</tr>
</tbody>
</table>

*The exact well separation achievable is obtained from pre-survey modelling*
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High Resolution Imaging of coal seams

4 – 5 ft. Coal Seam
Conclusions

• Allows operators to drill and target the seams with more accuracy than is possible with any other technique

• Strengthens reservoir understanding by integrating with other seismic measurements and frac monitoring (HFM)

• Allows a better understanding of often complex interbeded coal / shale sequences so the cleanest, highest-producing zones can be targeted

• Provides a detailed view of the natural faulted structures within the coal

• Time lapse crosswell seismic monitoring using velocity clearly indicates gas/fluid effects from methane extraction

• Xwell Seismic can be used in mining industry too for similar applications.
Thank You & Questions